



Technical Seminar: Solid Geometry Optimization and Meshing

Topics for Today:

- When You Have Technical Questions?
- Solid Geometry and Meshing Fundamentals
- Working with Solid Geometry
- Mesh like an Expert for Optimal Efficiency and Accuracy
- Mesh Repair (Everybody's Dirty Secret)
- Additional Resources

A Brief Q&A Period

April 1 2010



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When You Have Technical Questions?

- At Predictive we are your colleagues. We won't do your work for you but we will help you be a better and more knowledgeable user of Femap and NX Nastran. As one client told me "I have never had a technical support person tell me to go read the manual..."

- GTAC is online with offices on the East and West Coasts. They are good people. They won't tell you to go read the manual.

- We enjoy debugging models that won't run, odd meshing problems, idealization challenges with a new project, that is to say – engineering. Please don't expect us to train you over the phone on how to do a contact analysis or explain the differences between plate and beam elements. Again, we are your colleagues in the virtual cubical and w.r.t. training, we offer courses and have an extensive on-line library to assist you.

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Solid Geometry and Meshing Fundamentals

- ❑ A geometric solid is composed of surfaces, curves and points. One can break up a solid into individual surfaces. Each surface can be decomposed into a group of curves (well somewhat) and each curve has points at its terminus. Solids can be sliced and diced and exploded and stitched and extruded, etc.

- ❑ Meshing of geometric solids is all about the meshing of individual surfaces. Think surface meshing and you will know all that you need to know about meshing geometric solids.

- ❑ When meshing fails or you have an ugly rat's nest of elements, it always has something to do with a bad surface. It is then just a quest to find these surfaces and deal with them by removing them, combining them with adjacent surfaces or rebuilding the geometry. Femap gives you almost too many options.

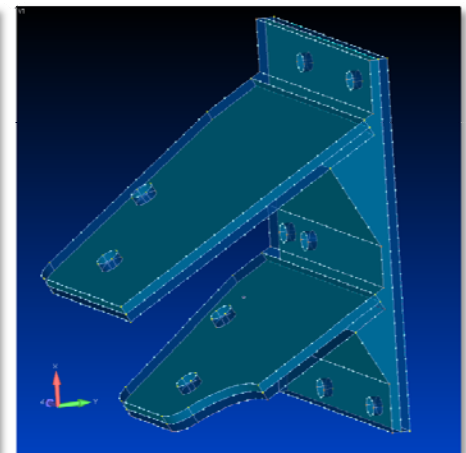
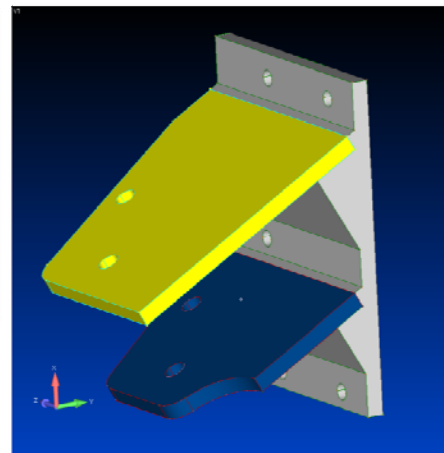
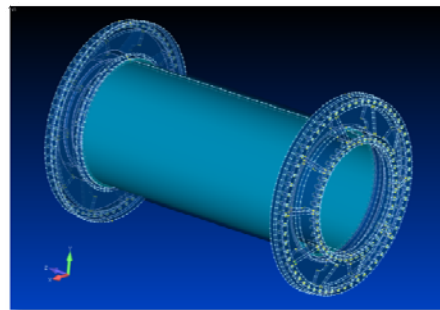
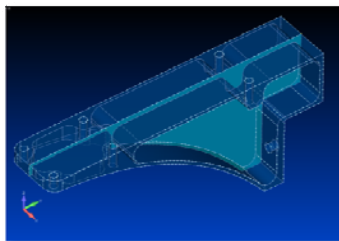
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Working with Solid Geometry

- ❑ A large and complicated piece of geometry will often mesh much faster if split into smaller chunks.
- ❑ The meshing of perfectly connected geometry works through the magic of slaving surfaces together into pairs where the mesh is transfer from the master to the slave (hey – what else do you expect from a bunch of male engineers in 1970?)
- ❑ One can create better meshing with clever geometry operations.
- ❑ If the surfaces don't match you can't automatically pair'em.



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Mesh like an Expert for Optimal Efficiency and Accuracy

- ❑ Don't get into a rush when meshing a complicated part. A bit of time up front can save you hours downstream.
- ❑ A quality mesh is has substantial benefits in the quality of the analysis work and execution time. Don't believe all the fancy marketing B.S. – we are still working with isoparametric elements with basic Guassian Integration.
- ❑ Femap's meshing toolbox can do wonders and the new Mapped Mesh Feature (v10.1.1)

Finite Element Technology
General All Purpose Elements: Isoparametric Elements

In order to develop stiffness equations, we must be able to map displacements within the solid element from its nodal locations.

$$\mathbf{u}_{xp} = \sum_{i=1}^4 N_i(\xi, \eta) \mathbf{u}_{xi}$$

$$\mathbf{x}_{xp} = \sum_{i=1}^4 N_i(\xi, \eta) \mathbf{x}_{xi}$$

N_i is known as the shape function, which does double duty as the interpolation function for both displacements and coordinates.

$\eta = \text{eta}$
 $\xi = \text{xi}$

An example of a linear shape function: $N_1 = \frac{1}{4}(1-\xi)(1-\eta)$

Finite Element Technology
General All Purpose Elements: Isoparametric Elements

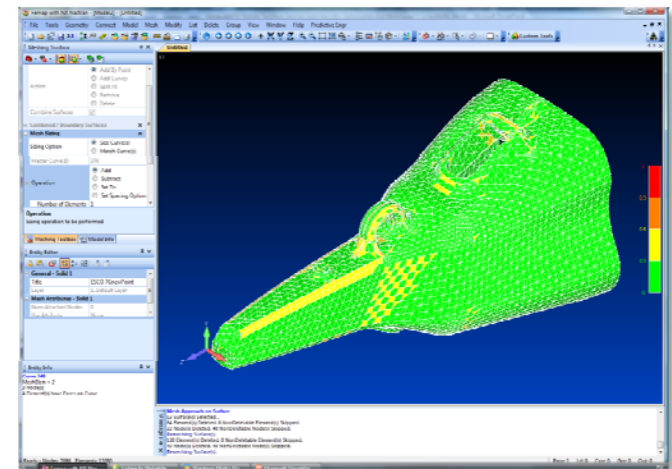
Gaussian integration points - if we didn't use them - we would be hurting in a big way. This technique is also known as Gauss Quadrature.

$$[\mathbf{k}] = \int_{-1}^1 \int_{-1}^1 [\mathbf{B}]^T [\mathbf{E}] [\mathbf{B}] [\mathbf{J}] d\xi d\eta$$

Numerical integration will use thousands of CPU cycles solving for "k"

Gaussian Integration:
$$\mathbf{I} = \sum_{i=1}^n \sum_{j=1}^m W_i W_j \phi(\xi_i, \eta_j)$$

"We have skipped a bunch of math, but the theme is that a lot of the action happens at the Gauss points."



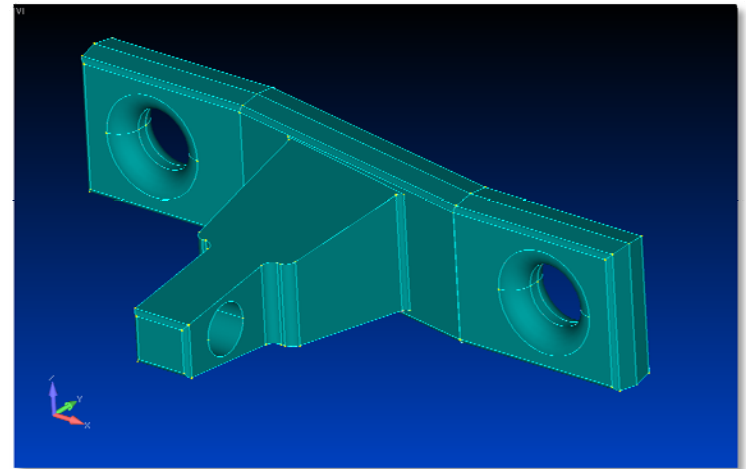
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Mesh Repair (Everybody's Dirty Secret)

- ❑ One can make demonstrations all day long showing how one can mesh the impossible. The reality is that sometimes...sometimes the geometry just won't mesh. Femap can mesh anything.
- ❑ Meshing is all about meshing surfaces first, then merging along the boundary of these surfaces, checking for tightness and then submitting this mesh to the tetrahedral mesher. Every FE program uses this algorithm.
- ❑ To fix a bad mesh, find the problem and fix it.



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Additional Resources

- ❑ Femap Examples on Meshing and Mesh Repair
- ❑ Predictive Engineering Web Site.

Working through the Examples

As there are many different types of real analysis problems, there are different types of example problems shown here. Generally, you should start with the first example in chapter 3 and work through the examples sequentially. Some of the later examples focus on specific techniques that you may not use in your work (beam modeling, axisymmetric modeling, midsurfacing). However, we recommend that you work through all the problems because they may contain some commands or techniques that you will find useful.

- [Analyzing Buckling for a Bracket](#)
- [Creating and Meshing a Solid Model](#)
- [Working with Groups and Layers](#)
- [Working with View Select and View Options](#)
- [Using Post-Processing](#)
- [Preparing Geometry for Meshing](#)
- [Repairing Sliver Geometry for Meshing](#)
- [Repairing a Mesh](#)
- [Analyzing a Beam Model](#)
- [Analyzing an Axisymmetric Model](#)
- [Analyzing a Midsurface Model of an Electrical Pipe](#)
- [Analyzing a Midsurface Model of a Welded Joint](#)
- [Direct Transient Analysis - Hinge Model](#)
- [Modal Frequency Analysis of the Hinge Model](#)
- [Frequency Response of Tower with Seismic Excitation](#)
- [Random Response of the Hinge Model](#)
- [Generation of Response Spectra - Single Degree of Freedom model](#)
- [Thermal Stress Analysis - Mounting Plate](#)
- [Steady - State Thermal Analysis - Circuit Board](#)
- [Steady - State Thermal Analysis - Free Convection](#)
- [Temperature - Dependent effects - Circuit Board](#)

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Tutorials / Downloads
This section provides a variety of tutorials and training files that will help you get up to speed using Femap.
The following files are designed to be used with Femap V8.3.1 or greater.
Choose from the categories on the left.

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Seminars

PSD (Power Spectral Density) v10.1.1 Tutorial Notes
Learn about solving random vibration problems with FEMAP 10.1.1. These vibrations can arise from earthquakes, tsunamis, acoustic excitation (e.g., rocket launches), wind fluctuations, or any loading which is inherently random. The vibrations are usually described in terms of a power spectral density (PSD) function.
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The NX Nastran linear contact video tutorial is presented for the experienced Femap user. It covers surface-to-surface interaction with friction. The tutorial provides some tips and tricks and discusses the theory behind the NX Nastran contact process. Key features discussed are: contact definition, contact property cards, regions and connector, contact convergence, geometric nonlinearity, solution times, contact search distance, plate element normals in contact region definition, and excessive pivot ratios. The Femap models used in the tutorials are also available to download.
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Linear Contact Surface-to-Surface
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The NX Nastran linear contact video tutorial is presented for the experienced Femap user. It covers solid-to-solid interaction with friction. The tutorial provides some tips and tricks and discusses the theory behind the NX Nastran contact process. Key features discussed are: contact definition, contact property cards, regions and connector, contact convergence, geometric nonlinearity, solution times, contact search distance, plate element normals in contact region definition, and excessive pivot ratios. The Femap models used in the tutorials are also available to download.

Latest Additions:
Added to Seminar:
The link below provide the training tools for the seminar on Working with Surfaces in Femap with NX Nastran. (Book file is Windows only and requires C2D codec)
Added to Seminar:
19199 - Zipped, Windows only
C2D Codec to view Movie
(Windows only)
PDF of Seminar
Geometry files
PSD (Power Spectral Density) v10.1.1 Tutorial Notes
Added to Tutorial:
Learn about solving random vibration problems with FEMAP 10.1.1. These vibrations can arise from earthquakes, tsunamis, acoustic excitation (e.g., rocket launches), wind fluctuations, or any loading which is inherently random. The vibrations are usually described in terms of a power spectral density (PSD) function.
Click to view (1.3 MB PDF File)
Added to Tutorial:
Quick and useful tips to make working with Femap with NX Nastran more efficient and more productive.
Download the PDF (2MB PDF)

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